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Signed Andrew Gursey

Dated 31 October 2003

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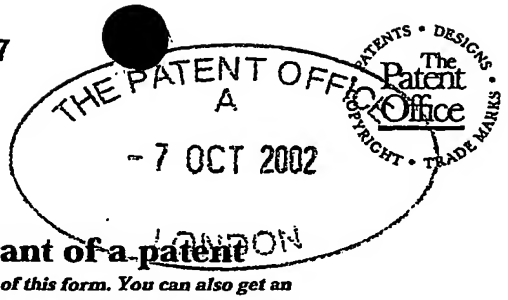

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P01/7700 0.00-0223222.1

Request for grant of a patent

(See the notes on the back of this form. You can also get an explanatory leaflet from the Patent Office to help you fill in this form)

The Patent Office

Cardiff Road
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1. Your reference 8629 CAH/gsw

2. Patent application number
(The Patent Office will fill in this part) 0223222.1

3. Full name, address and postcode of the or of each applicant *(underline all surnames)*

DIAMETRICS MEDICAL LIMITED
SHORT STREET
HIGH WYCOMBE
BUCKINGHAMSHIRE
ENGLAND HP11 2QH

Patents ADP number *(if you know it)* 7193345001

If the applicant is a corporate body, give the country/state of its incorporation UK

4. Title of the invention APPARATUS AND METHOD FOR MONITORING A PATIENT

5. Name of your agent *(if you have one)* Abel & Imray

"Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*

20 Red Lion Street
London
WC1R 4PQ
United Kingdom

Patents ADP number *(if you know it)* 174001

6. If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and *(if you know it)* the or each application number

Country	Priority application number *(if you know it)*	Date of filing *(day / month / year)*

7. If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application

Number of earlier application	Date of filing *(day / month / year)*

8. Is a statement of inventorship and of right to grant of a patent required in support of this request? *(Answer 'Yes' if:*

a) any applicant named in part 3 is not an inventor, or
b) there is an inventor who is not named as an applicant, or
c) any named applicant is a corporate body.
See note (d))

Yes

Patents Form 1/77

9. Enter the number of sheets for any of the following items you are filing with this form. Do not count copies of the same document

Continuation sheets of this form	
Description	12
Claim(s)	4 CF
Abstract	0
Drawing(s)	2 + 2

10. If you are also filing any of the following, state how many against each item.

Priority documents	
Translations of priority documents	
Statement of inventorship and right to grant of a patent *(Patents Form 7/77)*	
Request for preliminary examination and search *(Patents Form 9/77)*	
Request for substantive examination *(Patents Form 10/77)*	
Any other documents *(please specify)*	

11. I/We request the grant of a patent on the basis of this application.

Signature Abel & Imray Date 07.10.02

12. Name and daytime telephone number of person to contact in the United Kingdom: Dr Ceris Humphreys 01225 469914

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Notes

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b) *Write your answers in capital letters using black ink or you may type them.*

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Apparatus and method for monitoring a patient

The invention relates to an apparatus for monitoring the condition of a patient and to a monitoring method.

It is known that monitoring of certain parameters, for example, blood gas concentration (in particular pO_2, pCO_2 and pH), in bodily fluids can give useful information regarding the condition of a patient. In practice, such monitoring is carried out in many cases by taking samples from the patient at intervals and analysing each sample. Also known are so-called "continuous" monitoring devices, for example the device commercially available under the trade mark PARATREND, which have an elongate sensor portion which can be introduced into a blood vessel through a previously introduced catheter. The concentration of oxygen and carbon dioxide and the pH is monitored by optical sensing means housed in the sensor portion. Those devices enable the parameters to be monitored substantially continuously, so that attendant medical staff will become aware, without the delays inherent in sampling and sample analysis, of any significant change in patient condition. "Substantially continuously" as used herein is to be understood to include monitoring non-continuously at relatively high frequency, for example, at intervals of no more than five minutes, for example, not more than one minute, especially intervals

of not more than one second. Continuous monitoring devices may, with suitable modification, be inserted into soft tissue or introduced into organs for determining analytes in the tissue or organ in question.

The continuous monitoring devices mayrequire calibration before use. After insertion into the patient, re-calibration is not feasible, and the monitoring device may be susceptible to drift away from the calibration values. Whilst any such drift tends to be small, it is not unusual for the monitoring device to remain in the patient for a number of days so that, cumulatively, the drift may become material with the result that data measured a number of days after introduction of the device cannot reliably be compared with data measured shortly after its introduction.

The present invention provides an apparatus for monitoring a patient, comprising a sensor device for monitoring substantially continuously a parameter relating to a bodily fluid of the patient and an analyser device in communication with the sensor device for analysing a sample of bodily fluid withdrawn from the patient to derive information relating to the sample of bodily fluid.

References below to "sensor device" are to be understood as referring to a sensor device for monitoring substantially continuously a parameter relating to a bodily fluid of the patient.

The apparatus of the invention enables both substantially continuous monitoring of a parameter by the sensor device and intermittent ex vivo or in vitro analysis of samples of bodily fluid by the analyser device to be carried out, providing information from both sources for use by a clinician.

The information relating to the sample of body fluid is advantageously the parameter monitored by the sensor device. Advantageously, the apparatus is so arranged that information derived by the analyser device can be compared with measurements made by the sensor device. The data from the sensor device and the analyser device may be supplied to a common display device, at which each set of data is displayed and can be compared visually. If desired, the data from the sensor device and the analyser device may be supplied to a common processing means in which the comparison of the data is effected.

Whereas, in practice, measurements can be made by the sensor device essentially in real-time, measurements relating to a sample withdrawn from the patient will normally be available only after a delay, typically after the sample has been sent to a laboratory for analysis.

Advantageously, the measurements made by the sensor device are recorded and information derived by the analyser device relating to a sample of bodily fluid can

be compared with a measurement made by the sensor device substantially contemporaneously with the withdrawal of that sample. This enables a more reliable comparison to be made between the two sets of data, which may be particularly important where the parameter is changing at a material rate, for example because of a deterioration in the patient's condition.

Advantageously, the apparatus is such that comparison of the data from the analyser device with data from the sensor device can be used for calibration and/or re-calibration of the sensor device. Whilst in principle, a first calibration of the sensor device may be carried out based on comparison of readings from the sensor device, in situ in the patient, with readings from the analyser device, it may in practice be preferable for an initial calibration of the sensor device to be carried out before insertion of the sensor device into the patient, subsequent re-calibrations then being based on a comparison of readings from the sensor device in situ in the patient with readings from the analyser device.

Advantageously, the apparatus is arranged to effect automatic calibration and/or re-calibration of the sensor device when a difference between a value determined by the sensor device and a value determined by the analyser device in relation to the sample of bodily fluid is calculated in said comparison to be

outside a target tolerance range. The arrangement may instead be such that the data from the sensor device and the data from the analyser device is displayed and the calibration and/or re-calibration can be effected manually.

The apparatus may comprise an analyser device arranged to withdraw samples at predetermined intervals. The apparatus may be arranged to withdraw samples at, for example, regular intervals.

The apparatus may be arranged such that the samples can be withdrawn through the sensor device.

The sensor device and the analyser device may be suitable for determining any parameter suitable for providing information about patient condition. Preferably the sensor device can measure two or more parameters and the analyser device can measure at least two parameters that are also measured by the sensor device. Advantageously, the sensor device for substantially and the analyser device are each able to determine at least one parameter selected from pO_2, pCO_2, pH, Na^+, K^+, lactate, and glucose. Preferably the sensor device comprises at least sensing devices for determining pO_2, pCO_2, pH. The sensor device may also include a temperature measuring device, for example, a thermocouple. Advantageously, the sensor device is suitable for insertion into, and the analyser device is suitable for analysing blood withdrawn from, a blood

vessel.

The sensor device may be, for example, an optical sensor device, although other forms of sensor device are also encompassed within the invention.

The monitoring of blood gas concentrations can be of particular relevance in patients undergoing critical care, for example post-operatively or following trauma. In such patients, detection of a reduction in the oxygen concentration and/or an increase in the carbon dioxide concentration in bodily fluids can give early determination of the condition of the patient enabling appropriate treatment to be implemented promptly. Even where samples are taken frequently, the analysis of the samples ex vivo means that there is a delay between sampling and provision of the results, and the results merely provide a "snapshot" view of the patient's condition.

One illustrative embodiment of the invention will now be described in detail, with reference to the accompanying drawings in which:

Fig. 1 is a block diagram of an apparatus according to the invention; and

Fig. 2 is a flow diagram of a patient monitoring method using the apparatus of Fig. 1.

The apparatus comprises a sensor device 1 having a sensor probe which is suitable for insertion into a blood vessel of a patient to be monitored. For example,

the sensor device may be a Paratrend (trade mark) continuous blood monitor manufactured by Diametrics Medical Limited, which is suitable for monitoring oxygen (pO_2) and carbon dioxide (pCO_2) concentration and pH in blood. The sensor device is calibrated, for example, by placing the sensor probe into a solution of known pO_2, pCO_2, and pH. The sensor device 1 is connected via a sensor interface device 2 to a monitor 3, on which the measured values can be displayed in graphical or numerical form.

The apparatus also comprises an analyser device 4 for analysing samples of blood withdrawn from the patient. For example, an analyser device may be an IRMA (trade mark) device made by Diametrics Medical Inc. The IRMA is a blood analysis system in which a sample of blood can be withdrawn from the patient and placed in a cartridge which is arranged to be received in a sample space in a blood analyser where automatic analysis of the sample for various blood analytes can be carried out in vitro, including determination of pO_2, pCO_2, and pH. The analyser device 4 is connected via an analyser interface device 5 to a monitor 3, which in Fig. 1 is the same monitor as that to which the sensor device 1 is connected.

In the embodiment of Fig. 1 the sensor device 1 and the analyser device 4 are in communication with each other via the monitor 3, which may contain a processor

for processing data received from the sensor device 1 and the analyser device 4. The apparatus comprises a sensor clock 6 in communication with the sensor device 1. The sensor clock 6 is shown in Fig. 1 as being associated with interface device 2 but may instead be integrated into the sensor device 1 or monitor 3. The apparatus also has an analyser clock 7 in communication with the analyser device 4. The analyser clock 7 may be associated with interface device 5 as shown in Fig. 1, but may instead be integrated into the analyser device 4 or monitor 3.

In use, after calibration, the sensor probe of the sensor device 1 is introduced into a blood vessel of the patient, for example, a radial or femoral artery.

The control device (the control device may be within one of, or distributed throughout, the sensor device 2, monitor 3 and analyser 4)enables synchronisation of the sensor clock 6 and the analyser clock 7. The sensor device 1 commences substantially continuous collection of data relating to the analytes of interest in the blood and the data is passed via sensor interface unit 2 to monitor 3 where, after processing, it is displayed on the monitor 3. The control device registers readings from the sensor clock 6 and those readings are used to "time-stamp" the readings from the sensor device 1.

After substantially continuous monitoring for a suitable interval, for example, 30 minutes to 8 hours, a

sample of blood is withdrawn from the patient and immediately placed in the analyser device 4. The analyser clock 7 records the time of sample introduction as the sampling time. The analyser device 4 then proceeds to analyse the blood sample for various parameters, including at least one parameter that is being determined substantially continuously by the sensor device 1.

Following analysis of the sample by the analyser device 4, the measured values of the parameter or parameters and the sampling time are supplied to the control device. The control device scans the previously recorded data from the sensor device 1 and sensor clock 6 and identifies, based on the sensor clock data, sensor readings which had been recorded substantially contemporaneously with the sampling time. The sensor readings are compared with the measured values from the analyser device for the same parameters. The comparison may be carried out by the control device and a report displayed on monitor 3 or, if preferred, the relevant data from the sensor device 1 and the analyser device 4 may be displayed separately for visual comparison by a clinician.

If the comparison shows that the analyser data varies from contemporaneous sensor data by more than a desired amount, for example, by more than 5% of the value measured by the sensor, the sensor device

automatically re-calibrates the sensor probe 1 bases on the analyser values and data collection continues. If the difference from the analyser is smaller than the target value, data collection may continue without re-calibration.

The sampling and correlation steps are then repeated at appropriate intervals.

In practice, the measurement taken from a device such as the Paratrend device mentioned above will be affected only by a slow drift. Where such devices are used for relatively long periods in a patient, for example from 3 to 30 days, the cumulative drift over time may be material and re-calibration cannot be carried out whilst the sensor probe is in place in the patient. An appropriate regime for correlation of the sensor device readings with analyser device readings will depend on the particular condition of the patient.

One form of regimen is set out in detail in Fig. 2, and includes the following steps:

Step I - Negotiation between sensor device 1 and analyser device 4 to establish relative time.

Step IIa - Continuous data collection and data time-stamping by sensor device.

Step IIb - Time-stamping by analyser device 4 of sample taken from patient and evaluation of sample by analyser device 4.

Step III - Results of sample analysis and sample

time-stamp passed by analyser device 4 to sensor device 1.

Step IV - Processor instructed to effect correlation of data from analyser device 4 with data being collected continuously by sensor device 1.

Step Va - Correlation of data from sensor device 1 with data from analyser device 4.

Step Vb - Analyser device 4 awaiting acknowledgement from sensor device 1.

Step VI - Sensor device 1 confirming successful correlation to analyser device 4.

The above steps can then be repeated at intervals as appropriate.

In one regimen sample withdrawal and analysis and correlation of the sensor device 1 (if appropriate) based on analyser device readings may be carried out intermittently at regular intervals, for example, four-hourly or eight-hourly. In another suitable regimen sample withdrawal and analysis and correlation of the sensor device 1 (if appropriate) may be carried out intermittently at the convenience of the clinician, for example, to coincide with routine ward visits.

In the arrangement described above, samples are withdrawn manually by an attendant and placed in the analyser device 4. If preferred, the analyser device may be arranged automatically to withdraw samples and analyse them at predetermined intervals.

Further, it is also within the ambit of the invention for the time-stamped data from the sensor device 1 and the time-stamped data from the analyser 4 to be displayed separately, for example on separate monitors, and for the clinician to determine whether re-calibration is appropriate and initiate appropriate adjustment of the sensor device 1.

Claims

1. An apparatus for monitoring a patient, comprising a sensor device for monitoring substantially continuously a parameter relating to a bodily fluid of the patient and an analyser device in communication with the sensor device for analysing a sample of bodily fluid withdrawn from the patient to derive information relating to the sample of bodily fluid.

2. An apparatus according to claim 1, in which the information relating to the sample of bodily fluid is the parameter monitored by the sensor device.

3. An apparatus according to claim 1 or claim 2, the apparatus being so arranged that information derived by the analyser device can be compared with measurements made by the sensor device.

4. An apparatus according to claim 3, in which the measurements made by the sensor device are recorded and information derived by the analyser relating to a sample can be compared with a measurement made by the sensor device substantially contemporaneously with the withdrawal of that sample.

5. An apparatus according to claim 3 or claim 4, in which comparison of the data from the analyser device with data from the sensor device can be used for calibration and/or re-calibration of the sensor device.

6. An apparatus according to claim 5, which is arranged

to effect automatic calibration and/or re-calibration of the sensor device when a difference between a value determined by the sensor device and a value determined by the analyser device is calculated on said comparison to be outside a target tolerance range.

7. An apparatus according to claim 5, in which the data from the sensor device and the data from the analyser device is displayed and the calibration and/or re-calibration can be effected manually.

8. An apparatus according to any one of claims 1 to 7, which comprises a withdrawal device for withdrawing a sample for analysis by the analyser device.

9. An apparatus according to claim 8, which is arranged to withdraw samples at predetermined intervals.

10. An apparatus according to claim 8 or claim 9, which is arranged to withdraw samples at regular intervals.

11. An apparatus according to any one of claims 8 to 10, in which the samples can be withdrawn through the sensor device.

12. An apparatus according to any one of claims 1 to 11, in which the sensor device is suitable for insertion into, and the analyser is arranged for analysis of blood from, a blood vessel.

13. An apparatus according to any one of claims 1 to 12, in which the sensor device is an optical sensor device.

14. An apparatus according to any one of claims 1 to 13, in which the sensor device and the analyser device are

each arranged to determine a plurality of parameters.

15. An apparatus according to any one of claims 1 to 14, in which the analyser device and the sensor device are each able to monitor concentration of at least one blood analyte.

16. An apparatus according to claim 15, in which the analyser device and the sensor device are each able to monitor at least one blood gas.

17. An apparatus for monitoring a patient substantially as described herein with reference to and as illustrated by Fig. 1.

18. A method of monitoring a patient comprising monitoring substantially continuously a parameter relating to a bodily fluid of the patient using a sensor device, analysing a sample of that bodily fluid in an analyser device, comparing an analysis result obtained by the sensor device with an analysis result obtained by the analyser device, and effecting adjustment of data relating to the sensor device in dependence upon the comparison.

19. A method according to claim 18, in which said adjustment is effected automatically.

20. A method according to claim 18, in which said adjustment is effected manually.

21. A method according to any one of claims 18 to 20, in which the history of the substantially continuous measurements is recorded, and the comparison is effected

with the value of the substantially continuous measurement that obtained at the time of taking of the sample.

22. A method according to any one of claims 18 to 20, in which samples of the bodily fluid are withdrawn and analysed at intervals.

23. A method according to claim 22, in which the samples are withdrawn and analysed at predetermined intervals.

24. A method according to claim 22 or claim 23, in which samples are withdrawn and analysed at regular intervals.

25. A method according to any one of claims 18 to 24, in which at least one parameter selected from pO_2, pCO_2, pH is measured by the sensor device and the analyser device.

26. A method of monitoring a patient substantially as described herein.

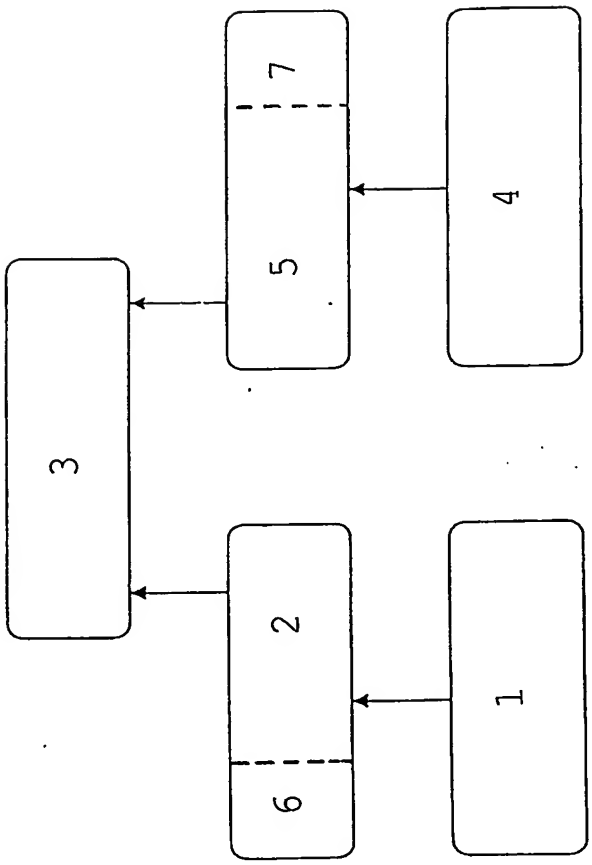

Fig. 1

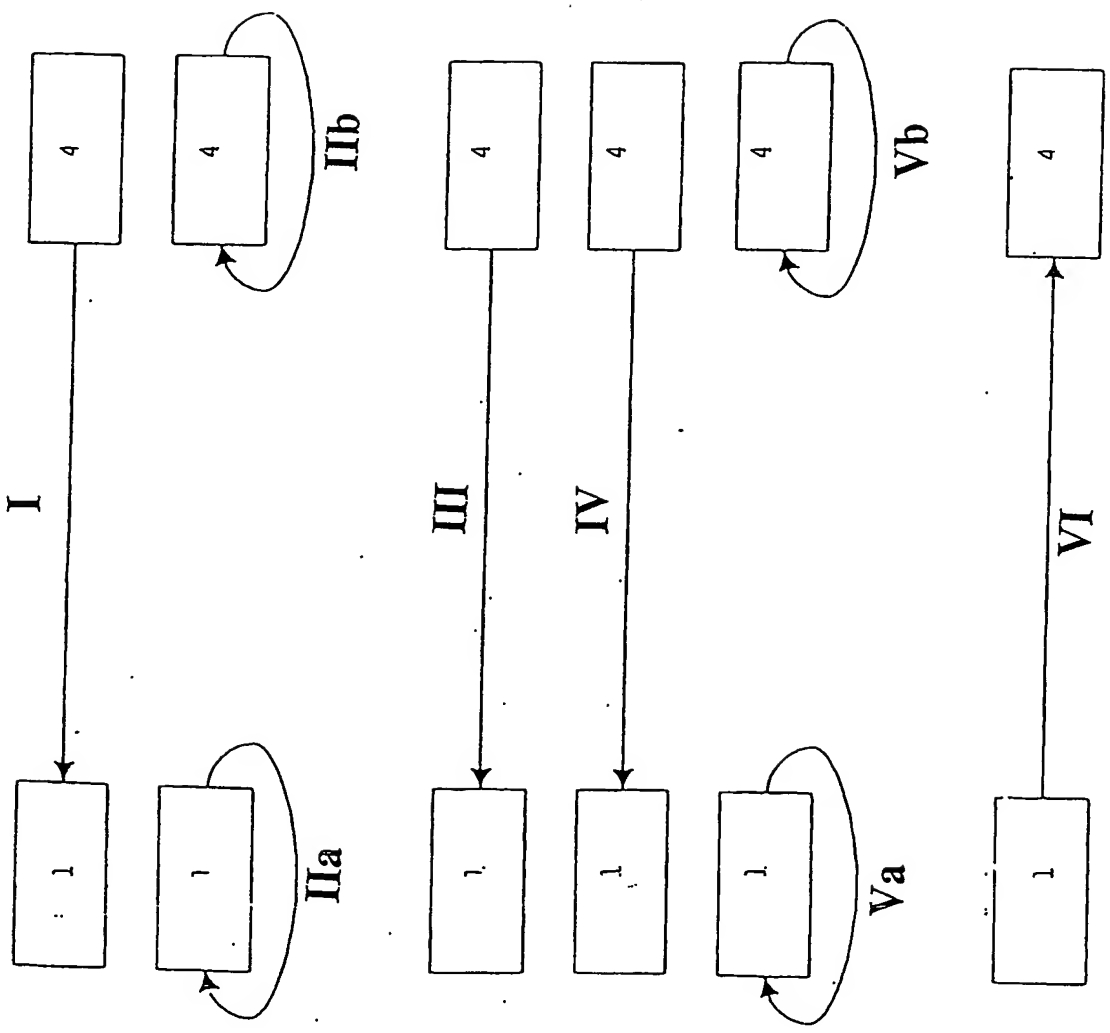

Fig. 2